III. "Iron and Steel at Welding Temperatures." By THOMAS WRIGHTSON, Memb. Inst. C.E. Communicated by Professor ROBERTS-AUSTEN, C.B., F.R.S. Received February 2, 1895.

(Abstract.)

The object of this paper is to demonstrate that the phenomenon of welding in iron is identical with that of regelation in ice.

The author recapitulates experiments made by him in 1879–80, described in the proceedings of the Iron and Steel Institute for those years.

These experiments were upon cast iron, and proved the fact that this form of iron possessed the property of expanding while passing from the liquid to the plastic state during a small range of temperature, and then contracted to the solid state, and that the expansion amounted to about 6 per cent. in volume.

The experiments were carried out under two distinct methods, the first being by the suspending of a cast-iron ball on a spiral spring, and lowering the ball under the surface of a vessel filled with molten iron of the same quality; the change of volume was registered by the contraction of the spring as the varying displacement of the ball varied its buoyancy.

The second method was by casting 15-in. spheres of cast iron, and measuring the changing diameter as the sphere cooled, then laying down on paper a curve of changing volume, which in general character was found to be similar to the curves produced by the instrument used in the first method.

This property of iron resembles the similar property of water in freezing, which, within a range of about 4° C., expands about 9 per cent. of its liquid volume, and then contracts as the cooling proceeds.

This property of water was investigated by Professor James Thomson and by Lord Kelvin. The former showed that from theoretical considerations there was reason to expect that in the case of a body exhibiting the anomalous property of expanding when cooled and contracting when heated, it should be cooled instead of heated by pressure or impact.

Lord Kelvin investigated the problem experimentally as affecting freezing water, and completely demonstrated the truth of his brother's reasoning.

The experiments made by the author in 1879 and 1880 suggested the view that this property of ice was connected with the property of welding in iron, but this was only hypothetical, as the experiments had been made on cast iron, which, probably on account of the

presence of carbon, does not possess the property of welding. Further, it was not practicable to experiment with wrought iron in the same way as with cast iron on account of the difficulty of dealing with that substance in its liquid form.

Professor Roberts-Austen has, however, given metallurgical research a recording pyrometer, and this has enabled the author to resume the investigation at the Mint, where he had the advantage of Professor Roberts-Austen's assistance and advice. The method adopted was the heating of bars in an electric welder, and as soon as the junction of the bars was at a welding temperature, end pressure was applied by mechanical power, and the weld effected.

The temperature at the point of welding was observed by placing a thermo-junction at this point consisting of a platinum wire twisted into a second wire of platinum alloyed with 10 per cent. of rhodium. The electric current produced at the thermo-junction deflected a galvanometer, which by means of a mirror threw a spot of light upon a sensitised plate which moved by clockwork uniformly in a direction transverse to the spot of light. This produced a curve, the ordinates of which represented time and temperature.

These curves appear to show that a molecular lowering of temperature took place immediately the pressure was applied to the bar when in the welding condition.

Photographic curves are exhibited which show that this fall in temperature varied in these particular experiments from 57° C. to 19° C., according to the circumstances of temperature and pressure.

This appears to prove that wrought iron at a welding temperature possesses the same property of cooling under pressure which was proved by Lord Kelvin to exist in freezing water, and on which demonstration the generally received theory of regelation depends.

The author distinguishes the process of melting together of metals from that of welding.

Either process forms a junction, but the latter takes place at a temperature considerably below the melting point.

The well-known and useful property of welding in iron appears, therefore, to depend, as in the case of regelation in ice, upon this critical condition, which exists over a limited range of temperature between the molten and the plastic state.